

## **PULMONARY BAROTRAUMA DURING HYPOXIA IN A DIVER WHILE UNDERWATER**

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### **ABSTRACT**

The article describes a diver performing a dive at small depths in a dry suit, breathing from a single-stage apparatus placed on his back. As a result of training deficiencies, the diver began breathing from inside the suit, which led to hypoxia and subsequent uncontrolled ascent. Upon returning to the surface, the diver developed neurological symptoms based on which a diagnosis of pulmonary barotrauma was made. The diver was successfully treated with therapeutic recompression-decompression.

**Keywords:** diving, accident, hypoxia, pulmonary barotrauma.

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## INTRODUCTION

In recent years, we can observe a continuous dynamic development of diving technology. At the same time, the spectrum of works carried out by scuba divers for the maritime economy and the armed forces is expanding. Unfortunately, the number of diver-specific illnesses and diving accidents remains on the rise [1,3,10].

Underwater work is characterised by considerable dynamic effort, associated with significant oxygen consumption and correspondingly increased pulmonary ventilation [3,7]. In hyperbaric conditions, the main factor limiting the scope of performed activities is a significant impairment of ventilation associated with an increase in respiratory resistances [4,17]. Therefore, in the case of divers equipped with diving gear, considerable physical effort, as well as emergency situations, may cause them to be exposed to conditions of acute hypoxia, i.e. hypoxia with simultaneous excessive accumulation of carbon dioxide in cells or hypercapnia [3,4,6,9,16,22]. These conditions pose a threat to the health and life of scuba divers working underwater and may in some cases be the cause of other illnesses and diving accidents [14,16].

One of the diving diseases that may occur in a state of hypoxia may include pulmonary barotrauma, where due to excessive unilateral airway hypertension, the diver develops a pulmonary parenchymal injury and related symptoms [2,8,12,13,20], which may develop immediately and in some cases may develop slowly over the course of several hours [13,15], with minimal effort accelerating their occurrence [8,18].

To illustrate the above, we present a case study we have observed

## CASE STUDY

A seafarer diver, aged 21, dived with an instructor on 23.03.1977 to review the underwater part of the ship. Diving to a maximum depth of 10 metres they had lightweight equipment supplied with air and wore dry suits. Weather conditions: air temperature +5°C and water temperature +3°C around noon. The character of the work performed was defined as requiring moderate effort. He started diving with P-22 "Kajman" apparatus in PW-2 suit at 11.00 a.m. and after about 10 minutes, while changing the orientation of his body to the horizontal, he reported

that he suddenly experienced an "impact" from an increased amount of air flowing into his lungs during inhalation. Fearing a lung injury, he immediately pulled the mouthpiece out of his mouth and started breathing air from inside the suit for about 2 minutes. He does not remember further course of the incident whilst underwater, or the moment he broke the surface, and he exited the water without the help of a safety diver.

After leaving the water he regained full consciousness, started to experience a strong headache, dizziness and breathlessness. After a few minutes, these symptoms began to disappear and he disregarded them and did not see a doctor. Again, after about 90 minutes following completing the dive, the diver began to feel increased headaches, dyspnoea, paroxysmal cough and his sputum was stained with blood. With the above mentioned symptoms, he reported to the doctor who, on the basis of an interview and the fact of performing a dive on that day, referred the diver with the suspicion of a diving disease (unspecified) to the outpatient clinic of the Diver and Scuba Diver Training Centre of the Polish Army for consultation.

On admission, the doctor on duty reported the following: pale skin, breath accelerated to 24 per minute. Lung auscultation: bronchial murmur regular, alveolar murmur regular slightly increased with fine rales. Heart rate steady, weak-tension pulse of 96 per minute, BP 110/80 mmHg. On the basis of examination and interview, the diver was diagnosed with pulmonary barotrauma in the course of hypoxia. Immediate therapeutic recompression was applied (about four hours after the completion of the dive). The air decompression table III presented as Table 1 was used [21]. During recompression, after reaching the pressure of 4.5 ata, the patient reported that the ailments began to decrease, and at the pressure of 7 ata he started to feel well. The total time of recompression-decompression treatment was 31 hours 50 minutes. As a result of the applied treatment, the symptoms of the illness ceased completely. The diver was referred to the 7th Naval Hospital for further observation. After an 8-day observation, he appeared before the Garrison Military Medical Commission which recognised him as incapable of diving service with an established diagnosis of vegetative neurosis. Nevertheless, he was found to be able to serve on a ship.



## CONCLUSIONS

The interview and clinical symptoms in the observed case indicate that the diver sustained an accident while working underwater due to deficiencies in training. The cause of the accident was a change of body position. When on his back, a pressure difference occurred between the device on the inter-cylinder connector and the mouthpiece device connected to it by corrugated low-pressure hoses. In this position, inhalation is easy, supported by a pressure difference of several centimetres of water column between the device on the inter-cylinder connector and the mouth, resulting in an increased inflow of air into the lungs, which the diver described as a "strong impact" on the airways. This caused him to panic and switched off further air supply by removing the mouthpiece and breathing from inside the suit. In view of the small amount of air contained there, symptoms of hypoxia with hypercapnia occurred, with subsequent acceleration and deepening of breathing. In panic, the diver must have rapidly reduced the depth of the dive, which led to an occurrence of pulmonary barotrauma.

The above mechanism of pulmonary barotrauma is observed relatively rarely in diving practice, although some authors have observed cases of this type in scuba divers using closed or semi-closed circuit devices [1,15,16,18]. Attention is also drawn to the fact that hypoxic conditions are more frequent with this type of equipment, although in practice they have also been observed in emergency situations when diving with air apparatuses [3,16].

A serious shortcoming in the case observed was organisational negligence and, above all, a lack of adequate support on the part of the medical staff, which undoubtedly delayed the decision on treatment after the accident and, simultaneously, could have serious consequences for the health and life of the injured diver [11]. The presence of a doctor at the dive site in this case would make it impossible for a diver to disregard the symptoms incurred as a result of diving illness. The use of therapeutic recompression in this case, despite the lapse of several hours after the end of the dive, was effective; a complete recovery was accomplished.

It should be stressed that diving accidents, in particular with complications, can pose certain diagnostic difficulties for medical personnel, especially those who are unfamiliar with diving pathology, although this may also apply to those who are involved in diving on a daily basis. The use of preventive medical recompression is therefore justified [12,13,16,19]. As a side-note to the observed case, the following conclusions may be drawn:

1. Careful selection of seafarers for scuba divers operating within the Damage Control Plan on board ships is imperative.
2. The organisation of diving from the ship should be carried out in accordance with the rules of the diving service.
3. All underwater work carried out from the ship should be secured by doctors trained in the field of diving physiology and pathology at courses organised by the Institute of Marine Medicine of the Military Medical Academy in Gdynia.

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